Web Based Laboratory Manuals in Civil Engineering

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Abstract: This paper describes the creation of interactive web-based based laboratory manuals for a Strength of Materials course and an Introduction to Environmental Engineering class. The lab manuals are published on the World Wide Web, providing the opportunity for incorporating many novel aspects such as digital photographs, sound-clips, and video-clips, and hot linked or hypertext descriptions. The concept is that these manuals contain all of the basic information included in a standard printed laboratory manual with some additions that the use of electronic media allows. For a given experiment a series of electronic images show aspects such as the equipment to be used, the preparation of samples, etc. A video-clip of the actual experiment being performed may be included. A series of data sets actually generated by performing the experiments are included. Another feature of this manual is a series of pre-tests and post-tests on each topic to identify the student's level of competence for a given topic before and after doing the experiment. These tests allow the instructor to assess the effectiveness of each laboratory topic in enhancing student learning. Each experiment will have a clearly defined set of learning objectives, which will be reflected in the pre- and post-tests. If deficiencies are identified, the student will be referred to material about the particular topic, or to appropriate sections and pages of a variety of popular textbooks on the subject. Another feature of the proposed manual will be the opportunity for students to do some statistical analysis of their data. A set of data points generated in the lab by the student can be combined with the data provided on the web, and combined in a spreadsheet and some basic concepts such as the mean, the distribution, and confidence levels can be explored.

Keywords: Laboratory, Web-based, Multimedia, Courseware

1. Introduction

Strength of Material is a second-semester sophomore or first-semester junior level engineering class, and is required for all civil engineering majors, as well as most other engineering majors. The laboratory component of this class usually includes experiments in torsion, tension, compression, bending and buckling. Introduction to Environmental Engineering is a second-semester sophomore or first-semester junior level engineering class and is required for all civil engineering majors. The laboratory component of this class usually includes experiments in dissolved solids, biochemical oxygen demand and the temperature profile of the campus lake.

The web site was designed to present elements of theory, experimental procedure, data collection, data reduction, report writing and statistics. To accomplish this, the site combines text, illustrations, photographs, video-clips, sound, simulations, animations, hypertext descriptions, and hot-links to the internet, making it truly multi-media. The final product is published on the World Wide Web. This format provides the opportunity for incorporating many novel aspects into the lab manuals. The long-term goal of the project is to use the style and approach developed on this project as a template for the other civil engineering laboratory courses. Common elements to all of these laboratories include modules on laboratory safety, report writing, statistics and unit conversions. This site is located at http://civil.engr.siu.edu/Labs/.

The concept has potential use in a diverse range of university environments. The pedagogy promoted by our approach is to engage students in active learning, and to accommodate various learning styles. By focusing on the development of an interactive multimedia program for the laboratory component of the course, the laboratory can strengthen the important bridge between application and classroom theory. For laboratories equipped with the appropriate equipment, the site was designed with the expectation that students review various aspects of the web-site at different stages of the learning process. Prior to attending laboratory, students are expected to review the basic concepts of the associated theory and to experience a "virtual laboratory" prior to their actual hands-on experience.

For laboratories that do not have access to state-of-the-art equipment, the students can still investigate and link the theory, experimental methods, and data collection.

2. Background

Multimedia applications represent the best application of modern technology to education and training in all areas. Computer technology and multimedia applications are particularly relevant in engineering education [1,2]. They give students the opportunity for self-paced learning in an interactive environment [3]. The format is nonlinear; allowing the student to review certain parts in a manner that is much easier than with simple videotapes or audiocassettes. The effectiveness of computer-based instruction has been widely documented in numerous studies [4]. Multimedia instructional modules tend to engage students in active learning [5]. Student acceptance and usage of educational multimedia is high [6].

There has been a significant amount of work done in the area of multimedia and/or web based interactive learning modules in science and engineering. This work ranges from basic courses such as statics [7] and strength of materials [8], to advanced topics such as finite element analysis [9]. One area that has received considerable attention is manufacturing with some work done on laboratory applications [10]. Some work has also been done in the area of environmental engineering [11,12].

The topic of trying to supplement or replace basic engineering laboratories has also been studied. The concept of virtual engineering laboratories was introduced for electric circuits at Vanderbilt in a paper by Mosterman et al [13]. In the Civil Engineering area, Alani and Barnes discussed the development of a multimedia soils mechanics laboratory [14]; and the paper done by Kantz et al. [31] looks at some aspects of an introductory environmental lab.

3. Layout of the Web Site

The web site is laid out in three main sections. One is a set of pages that is common to all laboratory classes. The other two sections relate directly to the two labs, Strength of Materials and Introduction to Environmental Engineering. The open page of the web site is shown in Figure 1.

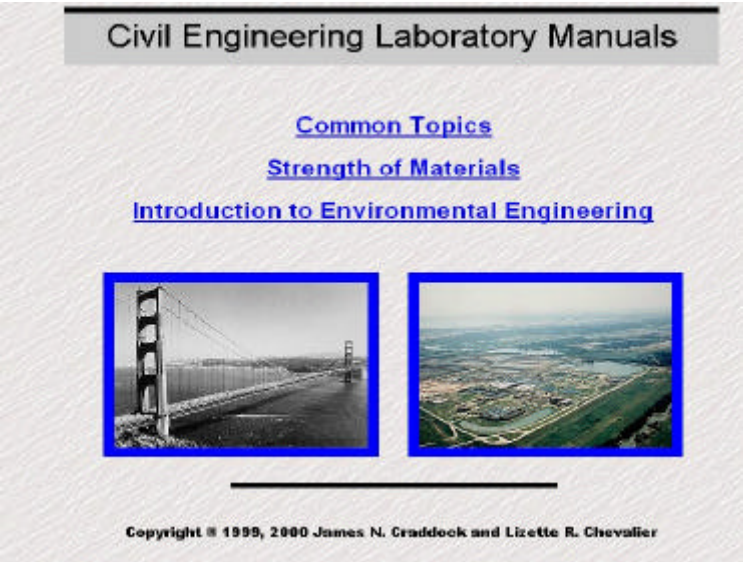

Fig. 1. The web-based laboratory manual opening screen

The common topics include material on writing a laboratory report, laboratory safety, statistics, and units. As the name implies, these are important topics that are useful in every laboratory class. The common topics page is shown in Figure 2. It can be seen that navigation within the web site is primarily done with a system of navigation buttons.

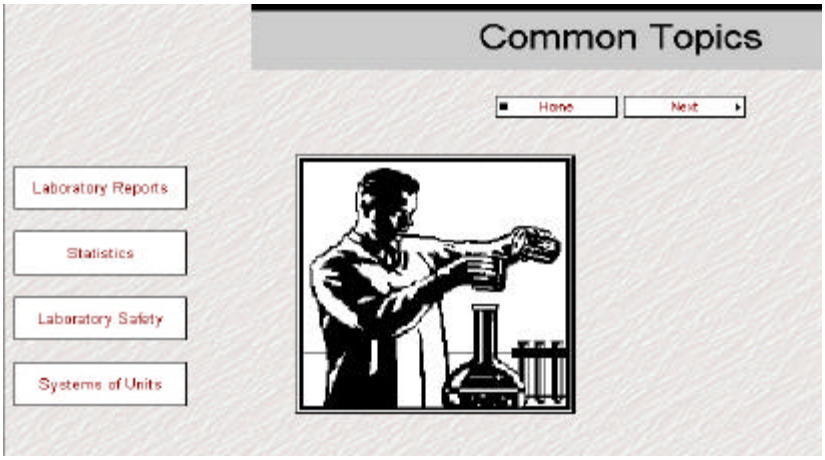

Figure 2. Common topics section of web site

One important topic in the development of this web site was the desire to include more basic statistics in the laboratory experience that has been done in the past. A concise review of basic statistics was created. This includes many examples and tips on how do the related statistical computations in a spreadsheet such as Microsoft EXCEL. This approach not only helps to integrate the use of statistics throughout the Civil Engineering curriculum, but also reinforces the computer skills of the students. Thus, many educational objectives can be accomplished with this approach. A portion of the statistics review is shown in Figure 3.

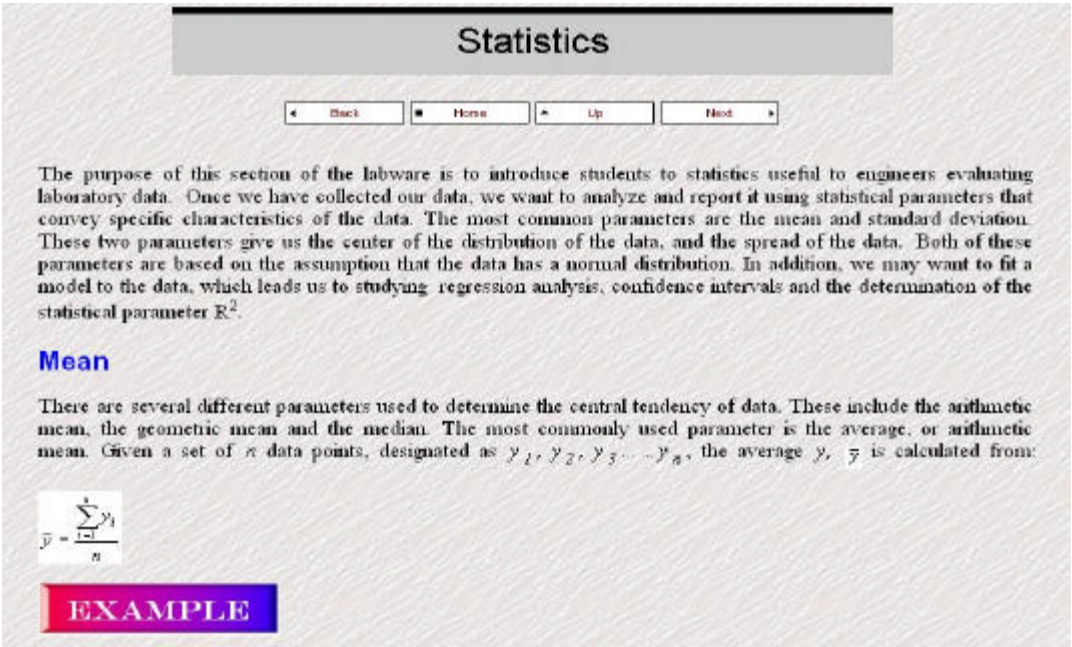

Fig. 3. Statistical review portion of the web-based lab manual

The strength of materials section of the site includes material such as terms and definitions and material properties that are used in every experiment in the class. Additionally, a section on every experiment is included. The five experiments covered are torsion, tension, compression, buckling and bending or flexure. The main page of the strength of materials portion of the site is shown in Figure 4. Again the use of navigation buttons allows the user to find their way around the site easily.

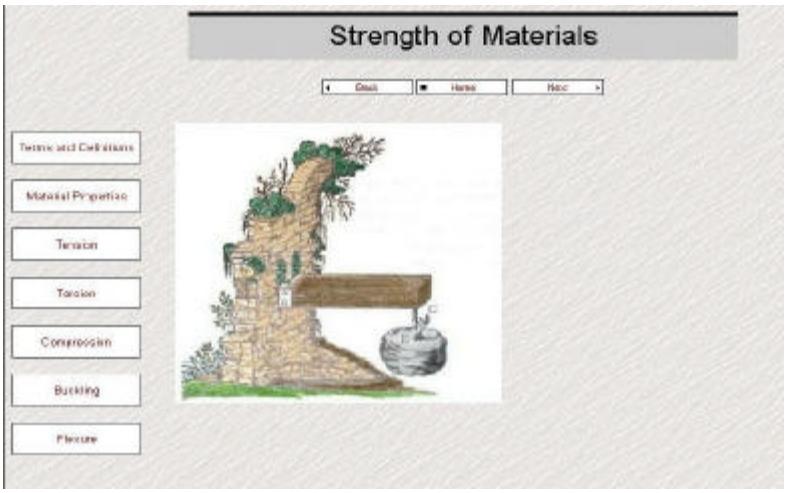

Fig. 4. Opening page of strength of materials laboratory manual

A similar layout is used for the Environmental Engineering section. This is shown in Figure 5. Here, only three experiments are currently considered. These involve suspended solids, biochemical oxygen demand, and the temperature profile of a local campus lake.

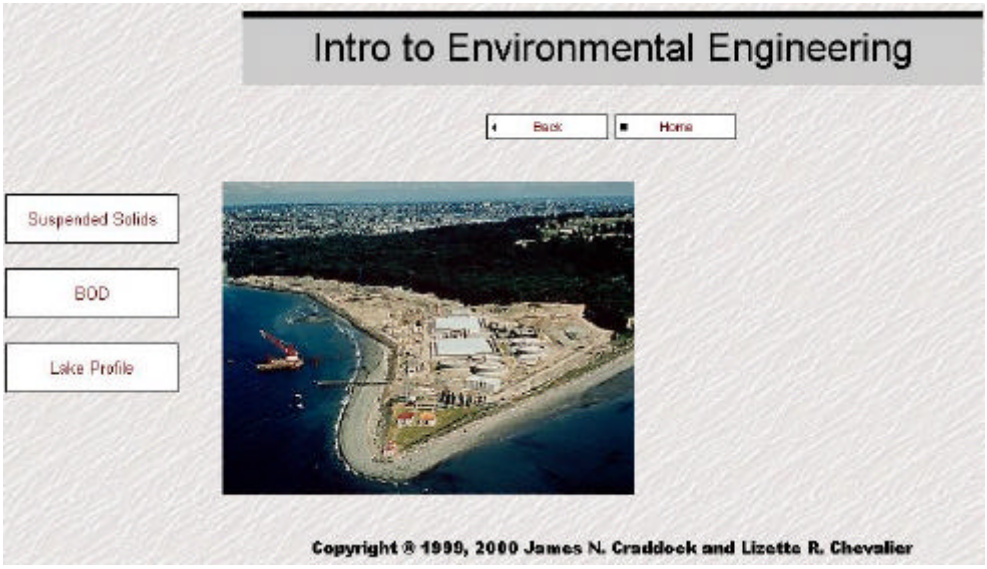

Fig. 5. Opening page of the introduction to environmental engineering site

Each experiment in either lab contains information about the theory and the experimental procedure involved in that experiment. Extra data sets are available for downloading. These data sets represent multiple runs of the experiment perhaps with different parameters than the students used. As an example, the torsion experiment uses four materials, steel, brass, aluminum and cast iron, but only one length and one diameter. The supplied data sets look at two lengths and three different diameters for each material. Thus, the students have access to more data than time and resources allow them to generate in the laboratory session. The multiple data sets can be incorporated with their own measured data to look at the statistical variations inherent in experimental work. The opening page of the torsion experiment is shown in Figure 6. Here, it can be seen that some traditional hypertext links are used as well as the navigation buttons.

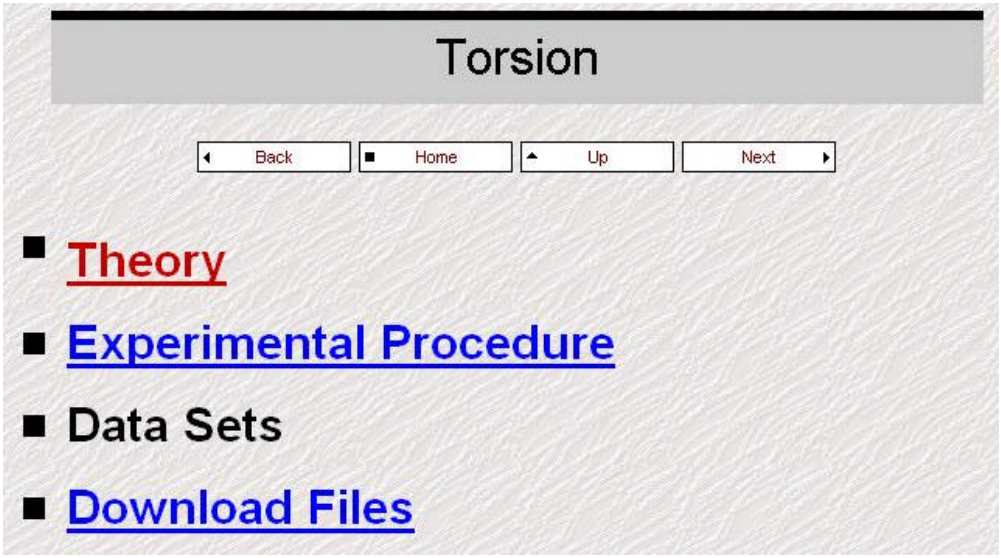

Fig. 6. Typical main page for an individual experiment.

4. Conclusion

The use of the web for presentation of a laboratory manual is very promising. Another alternative is the preparation of CD-ROM based manuals. The use of multimedia elements and hypertext links allows the presentation of much more information than a traditional printed lab manual. By planning a common site for all lab classes in the civil engineering curriculum, continuity is maintained. The use of multiple data sets allows the integration of statistics into the laboratory. While more work needs to be done, this is a very encouraging development and has been well received by the students.

5. References

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